

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

Chains, Rings and Spectroscopy

2814

Monday

19 JUNE 2006

Afternoon

1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:

Data Sheet for Chemistry

Scientific calculator

Candidate Name

Centre Number

Candidate
Number

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TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	12	
2	12	
3	12	
4	18	
5	12	
6	13	
7	11	
TOTAL	90	

This question paper consists of 16 printed pages.

Answer **all** the questions.

- 1** Leucine (2-amino-4-methylpentanoic acid) is a naturally occurring α -amino acid that is often used in protein supplements.

Leucine has a structural formula of $(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{NH}_2)\text{COOH}$.

- (a)** (i) State the general formula of an α -amino acid.

..... [1]

- (ii) Draw a displayed formula of leucine.

[1]

- (b)** Leucine can exist as a zwitterion.

- (i) State what is meant by the term *zwitterion*.

.....

..... [1]

- (ii) Explain with the aid of a diagram how the zwitterion is formed from the functional groups in leucine.

.....

.....

..... [2]

(c) Leucine can be obtained from a source of protein such as meat.

(i) State suitable reagents and conditions to break down a protein into amino acids.

.....
..... [2]

(ii) State the type of reaction occurring.

..... [1]

(d) Leucine can also be synthesised in the laboratory from simpler compounds.

(i) One reaction in this synthesis converts 2-chloro-4-methylpentanoic acid, $(\text{CH}_3)_2\text{CHCH}_2\text{CHClCOOH}$, into leucine.

State the reagents and conditions needed for this reaction.

..... [1]

(ii) Explain how a purified sample of leucine synthesised in the laboratory would differ from a sample of leucine purified from meat.

.....
.....
.....
.....
..... [3]

[Total: 12]

- An equation for the reaction is shown below.

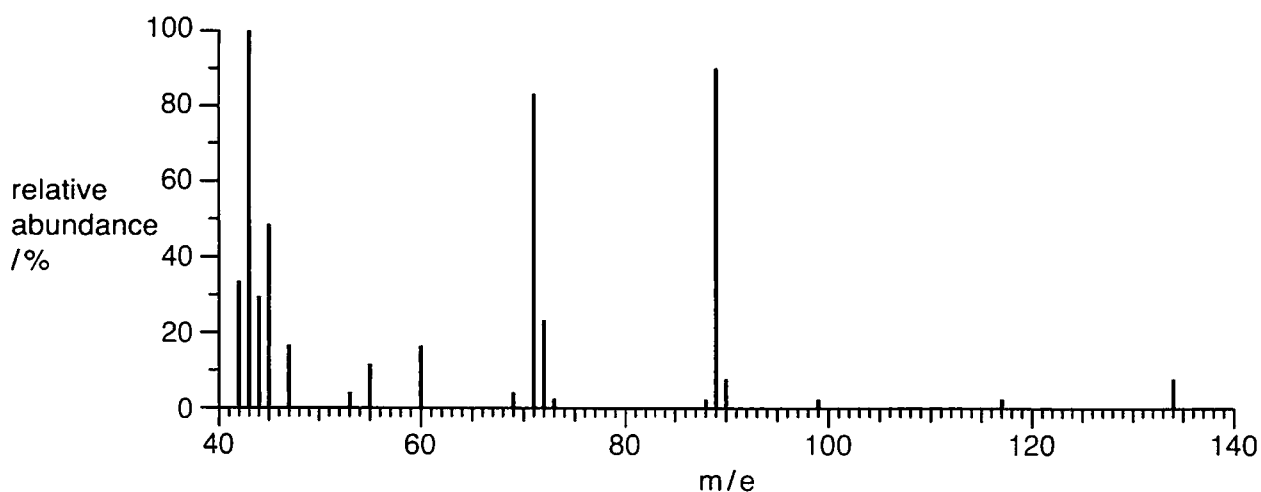


- (i) Identify the chiral centre on the structure of **malic acid** above using an asterisk *.
- [1]
- (ii) Draw a diagram to show the 3-D arrangement of groups around the chiral centre in malic acid.

[1]

- (b)** Wine can be analysed for the presence of these acids by mass spectrometry.

The mass spectrum of **malic acid** is shown below.



- (i) Draw a circle around the molecular ion peak on this spectrum of malic acid. [1]

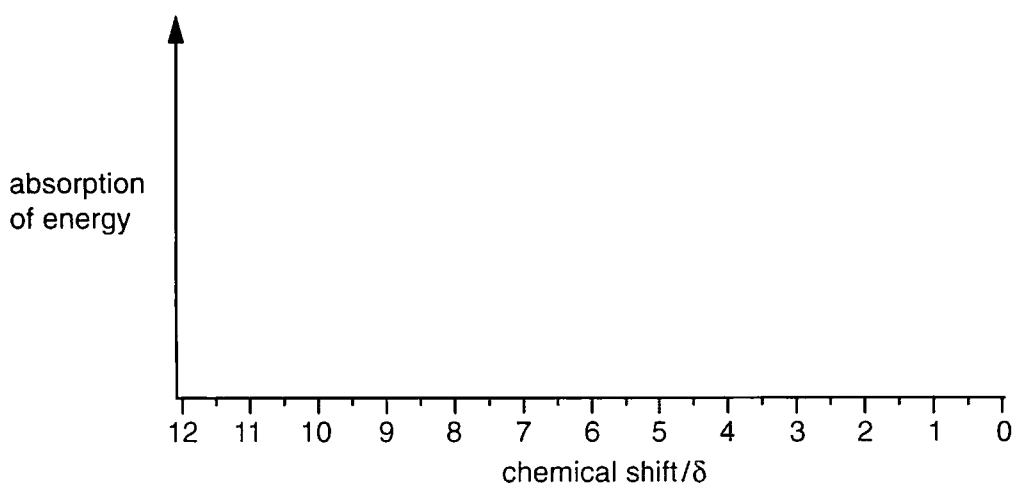
- (ii) Deduce the m/e value of the molecular ion peak of **lactic acid**.

.....
 [1]

- (c) Lactic acid produces an n.m.r. spectrum in D_2O with peaks at chemical shift values of 1.4 ppm and 4.3 ppm.

- (i) On the axes below, sketch the high resolution n.m.r. spectrum of lactic acid in D_2O .

Show any splitting patterns and state the relative areas of the two peaks. [4]



- (ii) How many peaks would you expect if the n.m.r. spectrum of lactic acid was run in an inert solvent rather than in D_2O ? Explain your answer.

.....
 [2]

- (d) As a wine ages, some of the acids slowly react with ethanol in the wine to produce esters.

- (i) Draw a displayed formula to show the structure of the ester formed when **lactic acid** reacts with ethanol.

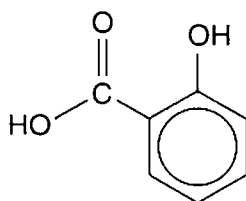
[1]

- (ii) Suggest what effect this process might have on the flavour of the wine. Explain your reasoning.

.....
 [1]

[Total: 12]

- 3 Salicylic acid is used in the manufacture of aspirin tablets. In the UK around 3500 tonnes of salicylic acid are manufactured per year.



salicylic acid

Salicylic acid is manufactured from phenol in three stages.

- (a) Phenol is first converted to sodium phenoxide, $\text{C}_6\text{H}_5\text{O}^- \text{Na}^+$.

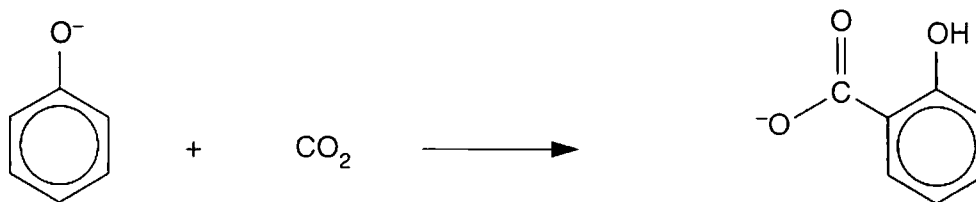
(i) State a reagent that could be used for this reaction.

..... [1]

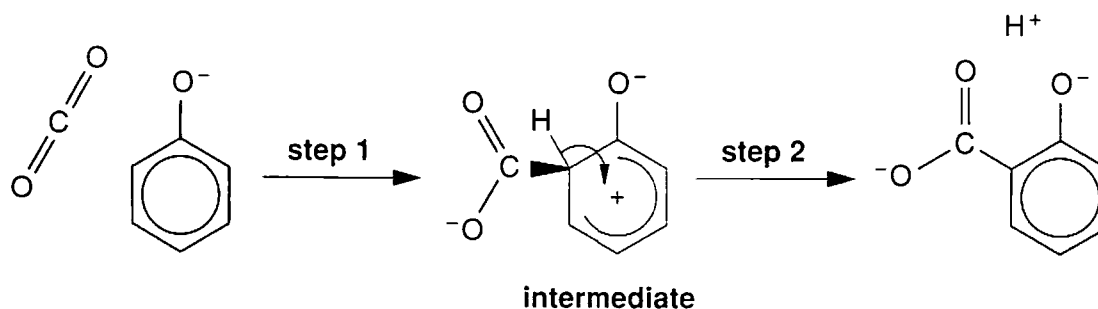
(ii) Write a balanced equation for this reaction.

[1]

- (b) The phenoxide ion is then combined with carbon dioxide under high pressure to form the salicylate ion.



This reaction is an electrophilic substitution reaction, which occurs by the incomplete mechanism shown below. Carbon dioxide acts as the electrophile.



- (i) Add partial charges δ^+ and δ^- to show the polarisation of the $\text{C}=\text{O}$ bonds in the carbon dioxide molecule above. [1]
- (ii) Complete the mechanism by adding curly arrows to show the movement of electron pairs in **step 1** to give the intermediate shown. [2]

- (iii) Carbon dioxide is normally a very poor electrophile. However, this reaction does occur because the benzene ring in the phenoxide ion is activated.

Explain how the benzene ring in the phenoxide ion is activated.

.....

.....

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..... [3]

- (c) In the final stage of this process, the salicylate ion is acidified to give salicylic acid.

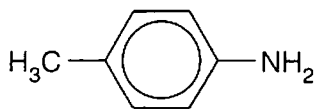
Assuming an overall yield by mass of 45% for this three stage process, calculate the mass of phenol that is needed to produce the annual UK output of 3500 tonnes of salicylic acid.

M_r of phenol = 94.0; 1 tonne = 10^6 g

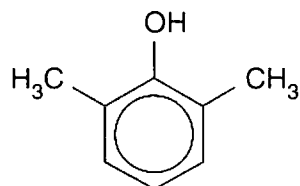
mass of phenol = tonnes [4]

[Total: 12]

- 4 A dye can be made from 4-methylphenylamine and 2,6-dimethylphenol, shown below.



4-methylphenylamine



2,6-dimethylphenol

4-Methylphenylamine is dissolved in ice-cold hydrochloric acid and sodium nitrite is added. This mixture is then slowly added to an alkaline solution of the phenol to form the dye.

- (a) (i) Identify the inorganic nitrogen-containing compound formed by the mixture of hydrochloric acid and sodium nitrite.

..... [1]

- (ii) Draw the structure of the organic compound formed in the ice-cold acidic mixture, showing a displayed formula of the nitrogen-containing group.

[1]

- (iii) State the name of the type of organic compound drawn in (ii).

..... [1]

- (iv) Suggest why the mixture must be kept at a low temperature.

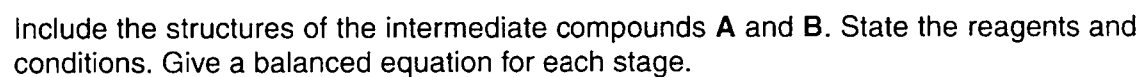
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..... [1]

- (v) Suggest the structure of the dye.

[2]

- 4-Methylphenylamine can be manufactured from benzene in three stages.

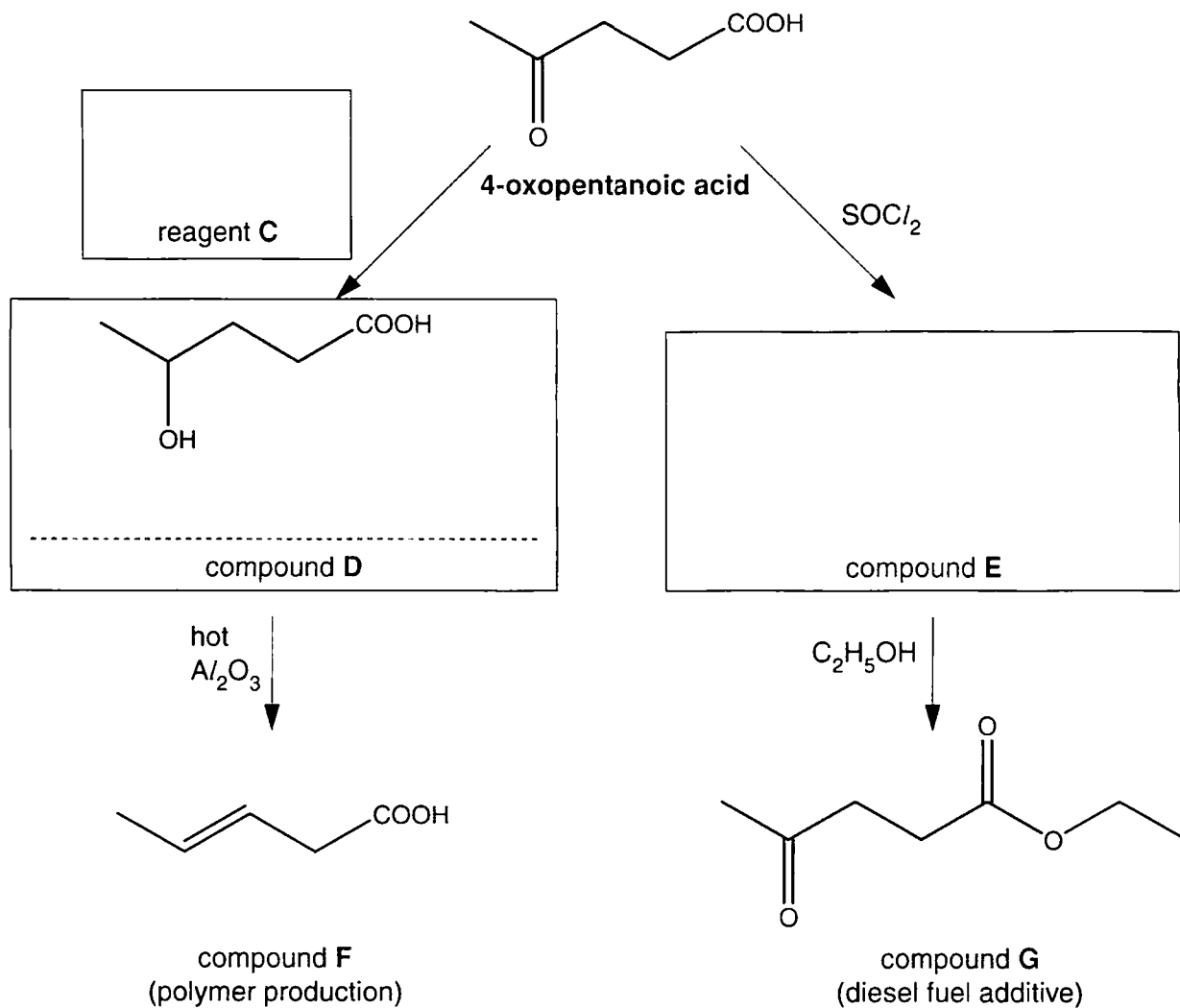


[11

[Total: 18]

- 5 Chemists are currently developing renewable sources of organic chemicals to replace diminishing crude oil reserves.

One process involves the conversion of plant material to 4-oxopentanoic acid. This can then be converted to other useful organic compounds, including those shown below.



(a) Complete the scheme by filling in the boxes to:

- (i) identify reagent **C** [1]
- (ii) state the name of compound **D** [1]
- (iii) draw the structure of compound **E**. [1]

(b) Compound **F** can be used to form a polymer.

(i) Draw a short section of this polymer showing at least three repeat units.

[1]

(ii) Draw a circle round one repeat unit on your structure.

[1]

(c) Compound **G** can be added to diesel fuel to reduce the amount of soot formed when the fuel burns.

(i) Deduce the molecular formula of compound **G**.

..... [1]

(ii) Write a balanced equation for the complete combustion of compound **G**.

[2]

(iii) Suggest how compound **G** reduces the amount of soot when the fuel burns.

.....

..... [1]

(d) If compound **G** is accidentally spilt, it is broken down rapidly in the environment by reactions such as alkaline hydrolysis.

(i) State the reagents and conditions that would normally be used for alkaline hydrolysis in the laboratory.

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..... [2]

(ii) Explain why compound **G** is able to be hydrolysed.

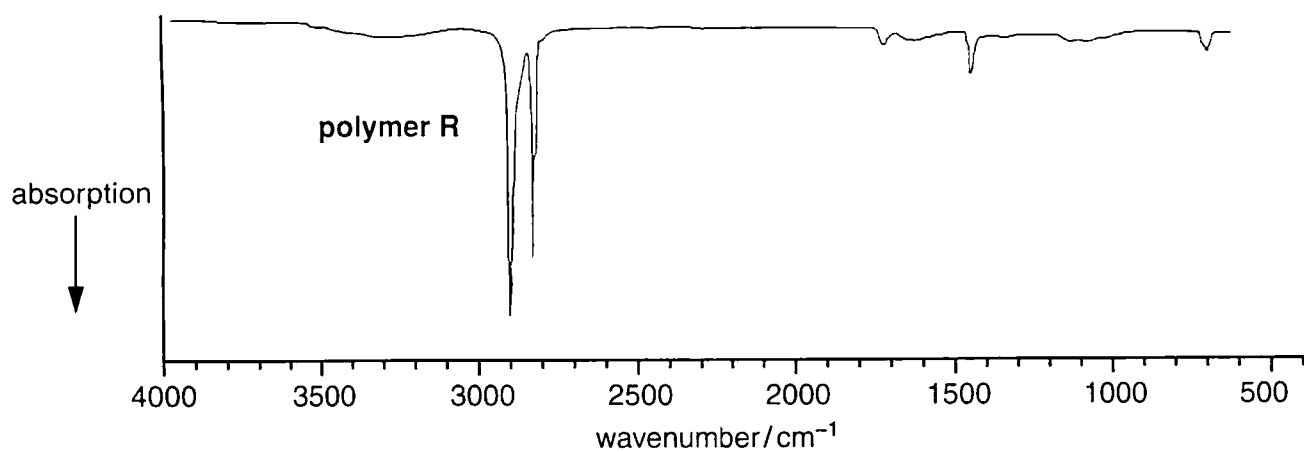
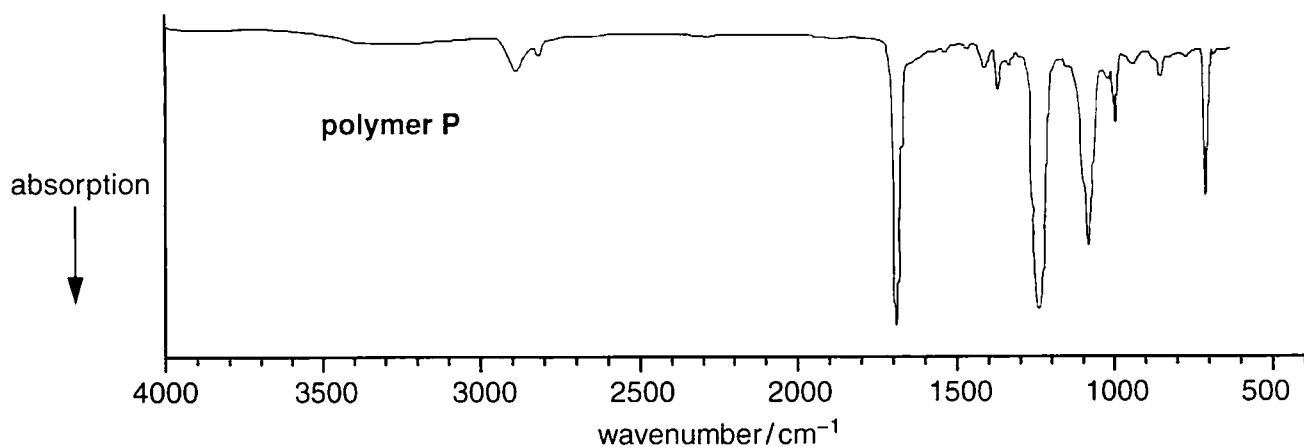
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..... [1]

[Total: 12]

- 6 Forensic scientists often use infra-red spectroscopy to identify very small fragments of polymers left at a crime scene.

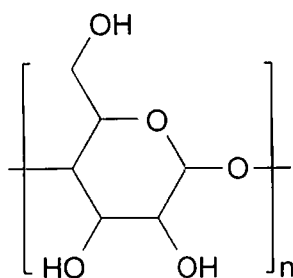
The infra-red spectra of two polymer samples **P** and **R** found at the scene of a crime are shown below.



The possible polymers are:

- a hydrocarbon polymer
- *Terylene*
- cellulose.

The repeat unit below shows the structure of cellulose.



cellulose

(a) *Terylene* and cellulose are condensation polymers used as fibres in clothing.

(i) State the type of condensation polymer used to make *Terylene*.

..... [1]

(ii) Draw the repeat unit of *Terylene* and describe how it is formed from its monomers.

[3]

(b) Identify polymer **P** and polymer **R**.

Explain your reasoning and comment on the presence or absence of any relevant peaks.

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..... [3]

(c) Two hydrocarbon polymers commonly used for household items and packaging are poly(ethene) and poly(propene).

Name the other hydrocarbon polymer in common use for packaging.

..... [1]

- (d) Poly(propene) used in disposable packaging is usually *atactic*. For more specialist uses, a *syndiotactic* form of the same polymer has been produced.

Describe how the structure of atactic poly(propene) differs from syndiotactic poly(propene). Use diagrams to illustrate your answer.

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[5]

[Total: 13]

- 7 In this question, one mark is available for the quality of spelling, punctuation and grammar.

The π -bond in carbonyl compounds reacts readily with nucleophiles, but not with electrophiles.

- Describe the π -bond in a carbonyl group and explain why this π -bond does **not** react readily with electrophiles. [4]
- Explain why carbonyl compounds react with nucleophiles and illustrate your answer by showing the mechanism for the reaction of methanal with a suitable nucleophile. [6]

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Quality of Written Communication [1]

[Total: 11]

END OF QUESTION PAPER

Copyright Acknowledgements:

- Q.2 The mass spectrum came from the NIST database at: [webbook](http://webbook.nist.gov/chemistry/) on 14/08/04.
- Q.6 The infra-red spectra were adapted from an article dated summer 2002, from the www.medlab.com website on 15/08/04.

OCR has made every effort to trace the copyright holders of items used in this Question paper, but if we have inadvertently overlooked any, we apologise.